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TESTS OF WING MACHINE-GUN AND CANNON

INSTALLATIONS IN THE NACA FULL-SCALE WIND TUNNEL

By K. R. Czarnecki and Eugene R. Guryansky
Langley Memorial Aeronautical Laboratory

SPECIAL REPORT #205

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$$K_x = \frac{5.60}{341} \\ = \frac{209}{341} \text{ lb} \\ = .534 \text{ lb.}$$

FOR THIS REPORT

TESTS OF WING MACHINE-GUN AND CANNON INSTALLATIONS IN THE NACA FULL-SCALE WIND TUNNEL

By K. R. Czarnecki and Eugene R. Guryansky

INTRODUCTION

At the request of the Bureau of Aeronautics, an investigation has been conducted in the full-scale wind tunnel of wing installations of .50-caliber machine guns and 20-millimeter cannons. The tests were made to determine the effect of various gun installations on the maximum lift and the high-speed drag of the airplane.

EQUIPMENT AND METHODS

A description of the full-scale wind tunnel and the equipment used in these tests is given in reference 1.

Barnett

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The airplane was a single-place Navy fighter with a gross weight of 5346 pounds and a wing area of 209 square feet. The wing sections vary from an NACA 23018 at the root to an NACA 23009 section at the tip. The basic condition of the airplane, shown in figure 1, differs from the service airplane in that it was equipped with a modified engine cowling that was sealed for the gun tests.

The high-speed drags were measured at a test speed of approximately 100 miles per hour and the maximum lifts were measured at a speed of approximately 58 miles per hour. All the maximum lift measurements were made with the flaps full down.

The effect of the machine-gun and cannon installations on the angle of stall and the maximum lift for each wing was determined from force tests and by means of a number of one-sixteenth-inch diameter static-pressure tubes which were mounted so as to measure the pressure gradient over the nose of the airfoil section. The stall was indicated by a sudden change in the wing-pressure distribution. Wool tufts were also used to indicate the nature of the air flow over the machine guns and cannons and to investigate flow breakdown.

MACHINE GUNS

The tests were made for five positions of the .50-caliber machine guns along the chord (fig. 2), including two flush-gun positions and gun-barrel extensions of 2, 10, and 18 inches ahead of the leading edge of the wing. Two heights of the machine guns above the chord line were tested. In the low vertical position (fig. 3) the center lines of the barrels were three-eighths inch above the chord line. In the high position (fig. 4) the center lines of the barrels were $1\frac{7}{8}$ inches above the chord line. The junctures of the openings for the gun barrels and the leading edge of the wing were faired by means of gun sleeves (fig. 5). A clearance of one-eighth inch existed between the gun barrels in all positions and the gun sleeves. In the flush-gun installations, the ends of the barrels were enclosed within the wing and the gun sleeves were flush with the contour of the wing.

At the four gun stations tested, the wing thicknesses were 10.7, 10.2, 9.6, and 8.9 inches. Leakage past the guns and through the ejector slots was eliminated by sealing the gun installations within the wing. Wooden blisters simulated the fairings for the gun breech and the mounting post as shown in figure 2.

Table I summarizes the results for all the machine-gun installations. The C_{Lmax} of 2.00 and the C_{DHS} of 0.0229 for the smooth airplane were used as reference values for estimating the effects of various gun installations. The C_{DHS} is the drag coefficient at the assumed high-speed lift coefficient of 0.2.

Most of the high-speed drag coefficients listed in table I are for four guns, either in the low position on the right wing or the high position on the left wing. It may be noted that the increments in high-speed drag coefficient, added by the various gun installations were, with two exceptions, not more than 0.0003 or about $1\frac{1}{2}$ percent of the airplane drag coefficient. These increments are only slightly greater than the experimental accuracy of the tests. Drag increments for the machine guns measured by the force method were in excellent agreement with those obtained by the wake survey method. (See reference 2.)

The $C_{L_{max}}$ with four flush guns in the high position (fig. 6) was only slightly lower than the reference value, but the $C_{L_{max}}$ was decreased 0.06 below the reference value with the flush guns in the low position (fig. 7). The combination of 10-inch-barrel extensions and the low-flush-gun mounting post and breech fairings (fig. 8) decreased the $C_{L_{max}}$ by 0.09. With these fairings removed, the $C_{L_{max}}$ was reduced 0.13 below the reference value. The $C_{L_{max}}$ for the 2-inch-barrel extension was decreased by 0.14 (fig. 9). By extending the gun barrels 18 inches ahead of the leading edge of the wing (fig. 10), the $C_{L_{max}}$ was decreased 0.09 below that for the reference condition.

With the barrels extended beyond the leading edge of the wing, the lower maximum lift measured for the 2-inch and 10-inch extensions is attributed to the fact that the disturbance caused by the ends of the gun barrels for the 18-inch extension passed above the wing at high angles of attack.

A combination of four machine guns in the low-flush position on the right wing and four in the high-flush position on the left wing did not appreciably affect the maximum lift.

CANNONS

Three 20-millimeter cannon installations were tested, including the underslung-wing cannon shown as cannon fairing 1, a modification shown as cannon fairing 2 (fig. 11), and the completely submerged installation (fig. 12).

Table II summarizes the results for the cannon installations. The drag coefficient for underslung installation 1 (fig. 13) was 0.0016 higher than that for the smooth condition, while the maximum lift coefficient was 0.09 lower. This installation was then modified by decreasing the width of the section near the leading edge of the wing and thereby reducing the abrupt pressure change at the front of the cannon fairing (fig. 14). The drag coefficient for underslung installation 2 was 0.0013 higher and the maximum lift coefficient was 0.05 lower than that for the basic

condition. By submerging the cannons within the wing (fig. 15), their drag increment was reduced to 0.0005, and the maximum lift coefficient was decreased by 0.04.

CONCLUDING REMARKS

Eight machine guns may be installed in a conventional wing without appreciably affecting the maximum lift or the minimum drag, if the installations are sealed and if the gun barrels do not protrude. The importance of sealing the installations to prevent air leakage either into or out of the wing was demonstrated in recent flight tests which showed that unsealed flush-wing gun installations appreciably reduce the maximum lift.

Sealed gun installations with barrels protruding 0.20c to 0.25c ahead of the wing lead to some adverse effects on the maximum lift and minimum drag; however, they are more favorable than installations with barrel extensions of 0.05c to 0.10c.

Installations can be made of two cannons that are submerged and sealed in the wing with barrel extensions approximately on the chord line that have only minor adverse effects on the maximum lift and minimum drag. Mounting the cannons in exposed fairings on the lower wing surface leads to substantial increases in the airplane drag.

The conclusions of these tests should be applied with caution to airfoils that are sensitive to leading-edge stalling. Further, the location of guns at positions on the wing at which the stalling normally begins may lead to greater adverse effects than are indicated in the present tests.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va.

REFERENCES

1. DeFrance, Smith J.: The N.A.C.A. Full-Scale Wind Tunnel. Rep. No. 459, NACA, 1933.
2. Goett, Harry J.: Experimental Investigation of the Momentum Method for Determining Profile Drag. Rep. No. 660, NACA, 1939.

The following confusing points are noted in Table 1, SR 245

- A. 4 guns mounted flush in the low position, with added skin friction of breech and mounting post fairings had less drag than the smooth wing. line (2).
- B. 4 guns mounted as above, but without the mounting post fairings has less drag yet (line (4))
- C. 8 guns, 4 "high" and 4 "low" had less drag with the fairings off than 4 guns with the fairings on [line (13) and (6)]

TABLE I

Test conditions						$C_{L_{max}}$	α at	$C_{D_{HS}}$	$\Delta C_{D_{HS}}$
Gun position	Wing	Gun stations	Barrel extension	Breech fairing	Mounting post fairing	flaps down	$C_{L_{max}}$ (deg)	at $C_L=0.20$	at $C_L=0.20$
Basic condition - smooth airplane						2.00	16.8	0.0229	Ref.
Low	Right	2,3,4	Flush	On	On	1.98	17.3	-----	-----
Low	Right	1,2,3,4	Flush	On	On	1.94	16.3	.0229	0.0000
Low	Right	1,2,3,4	Flush	On	On ^a	-----	-----	.0228	-.0001
Low	Right	1,2,3,4	Flush	On	Off	1.99	17.3	.0226	-.0003
Low	Right	1,2,3,4	10 in.	On	On	1.91	16.3	.0230	.0001
High	Left	1,2,3,4	Flush	On	On	1.99	17.2	.0232	.0003
Low	Right	1,2,3,4	Flush	On	On ^b	-----	-----	.0232	.0003
High	Left	1,2,3,4	2 in.	Off	On	1.86	15.5	.0230	.0001
High	Left	1,2,3,4	10 in.	Off	Off	-----	-----	.0231	.0002
Low	Right	1,2,3,4	10 in.	Off	Off	1.87	16.4	.0233	.0004
Low	Right	1,2,3,4	18 in.	Off	Off	1.91	16.6	.0232	.0003
High ^c	Left	1,2,3,4	Flush	On	On	1.96	17.4	.0234	.0005
High ^d and Low	Right and Left	1,2,3,4	Flush	Off	Off	2.00	17.4	.0230	.0001

^aModified mounting-post fairing.

^bModified flush installation.

^cModified gun sleeves.

^dLeft wing, high; right wing, low.

A.

TABLE II

Test conditions	Wing	Cannon fairing	Magazine fairing	$C_{L_{max}}$ flaps down	α at $C_{L_{max}}$ (deg)	C_D at $C_L=0.20$	ΔC_D at $C_L=0.20$	
Underslung installation 1	Right and Left	On	On	1.91	17.3	0.0245	0.0016	.0000
Underslung installation 2	Right and Left	On	On	1.95	16.8	.0242	.0013	.00070
Modified installation 2	Right and Left	On	Off	----	----	.0242	.0013	.00070
Completely submerged installation	Right and Left	On	Off	1.96	17.0	.0234	.0005	.00027

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Fig. 1

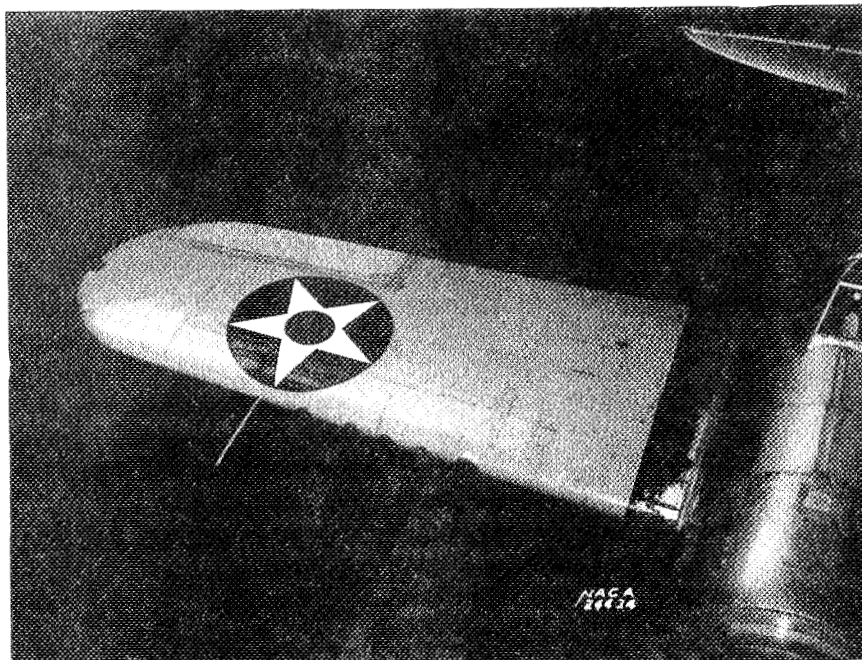
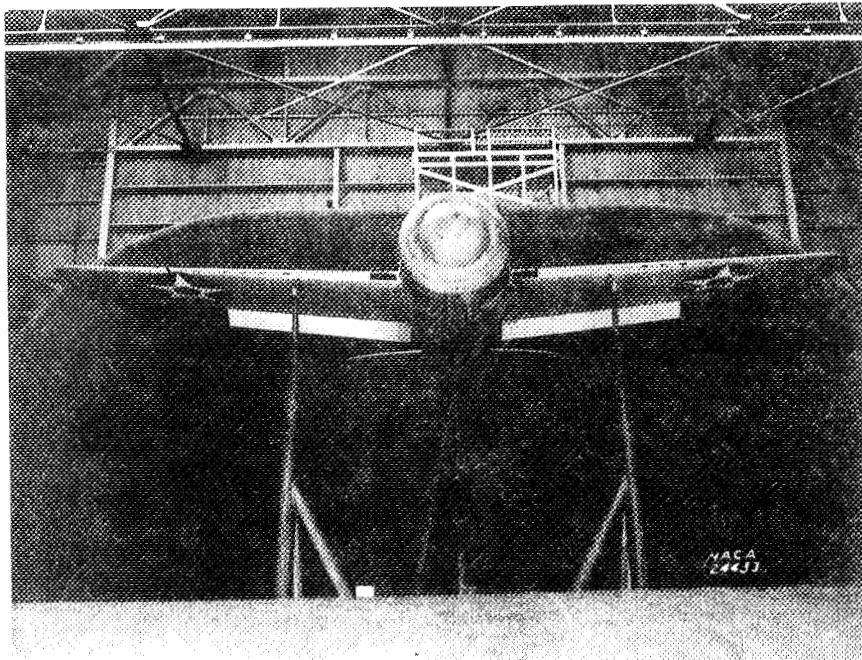


Figure 1.-- The airplane in the smooth condition with flaps down.

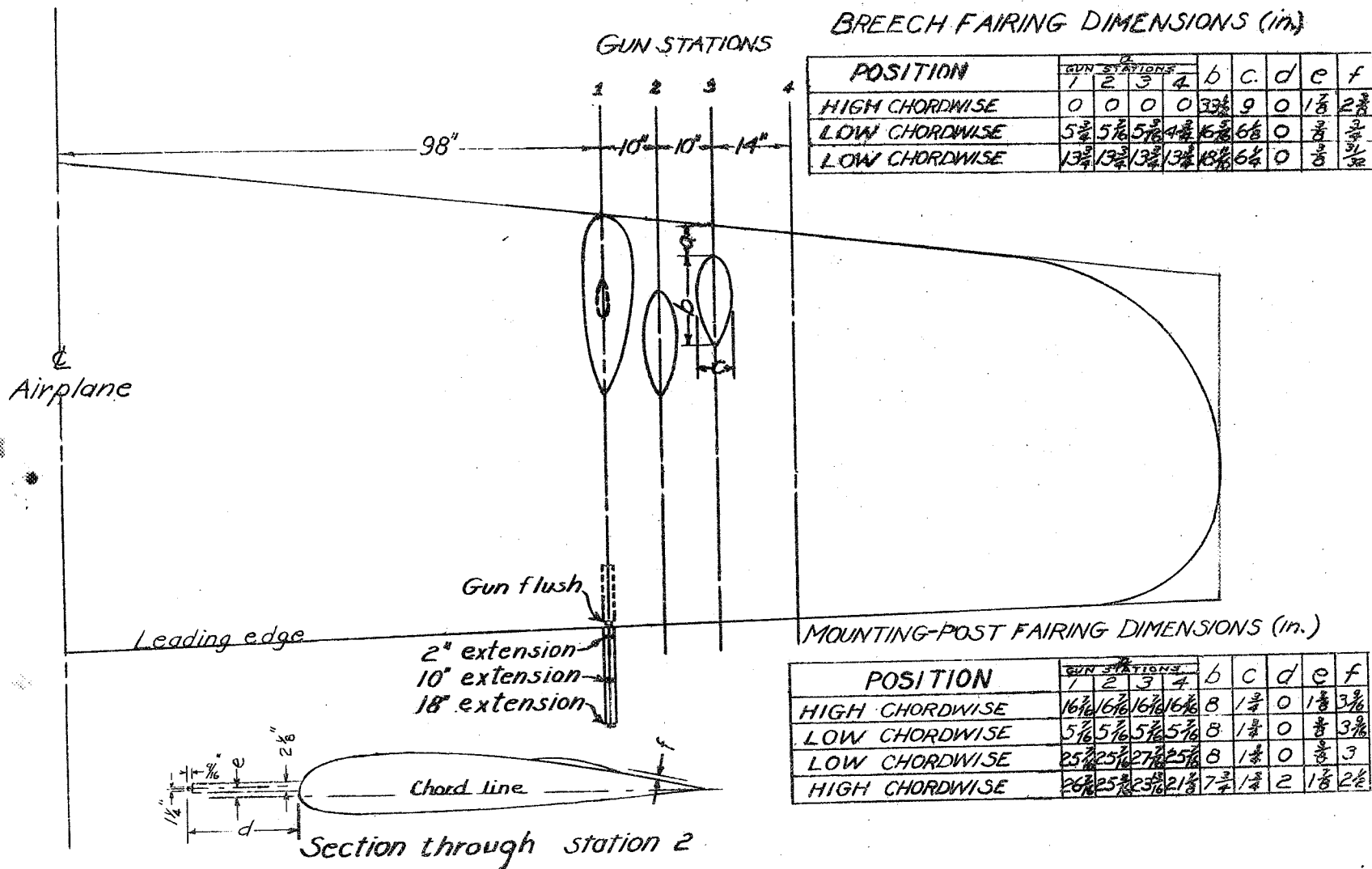


FIGURE 2.-BREECH AND MOUNTING-POST FAIRINGS FOR MACHINE-GUN INSTALLATION.

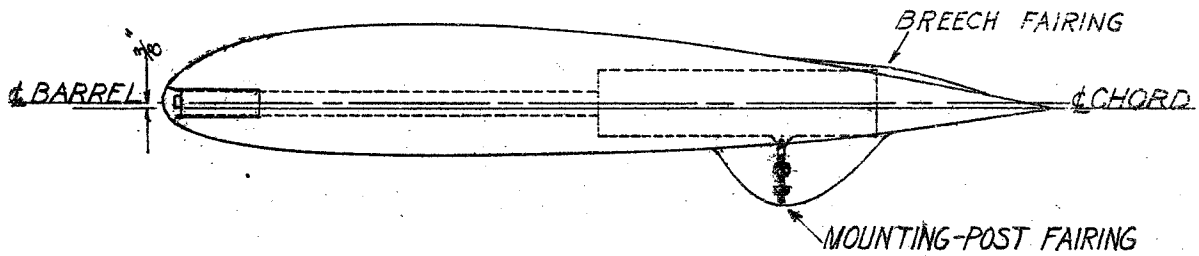


Figure 3.—The 0.50-caliber machine gun in low flush position.

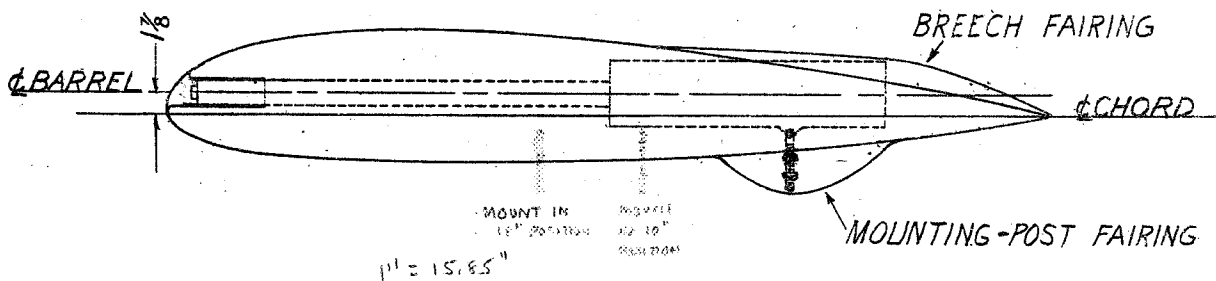


Figure 4.—The 0.50-caliber machine gun in high flush position.

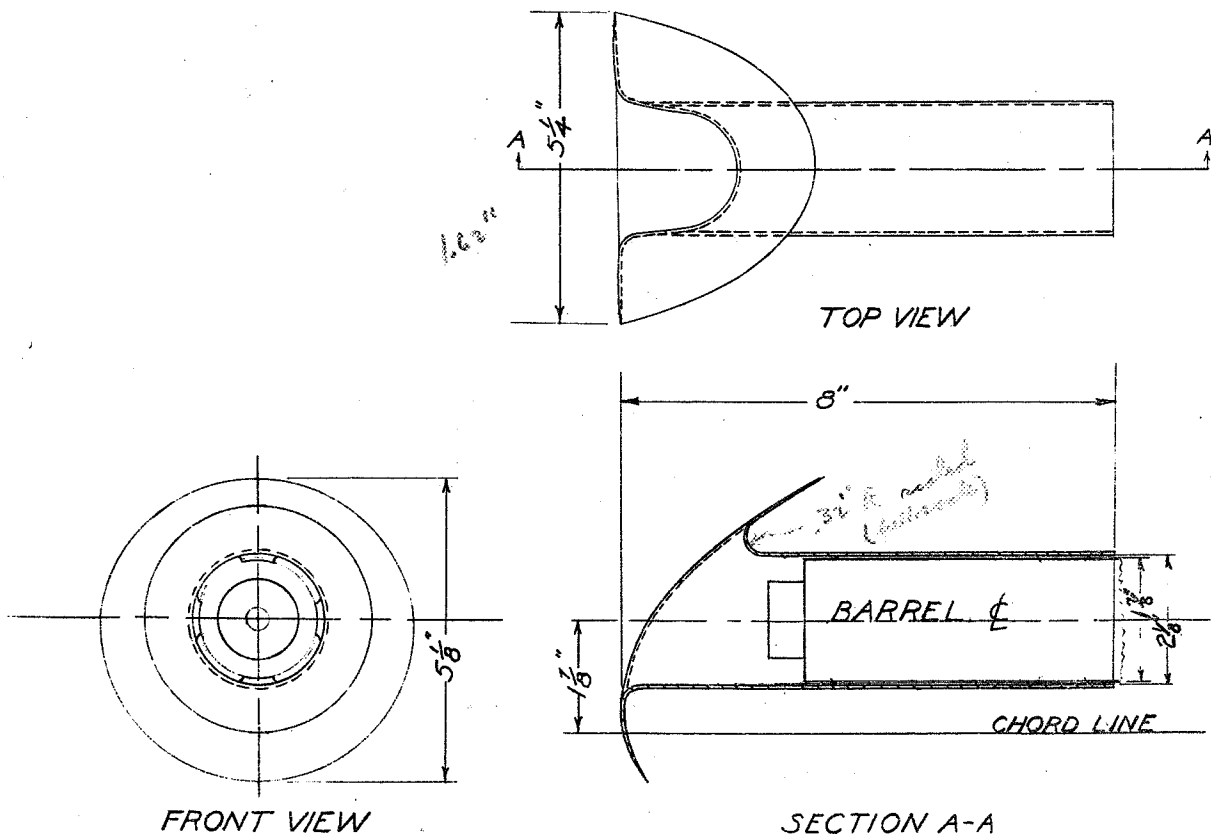


Figure 5. - Gun sleeve for high position of machine gun.

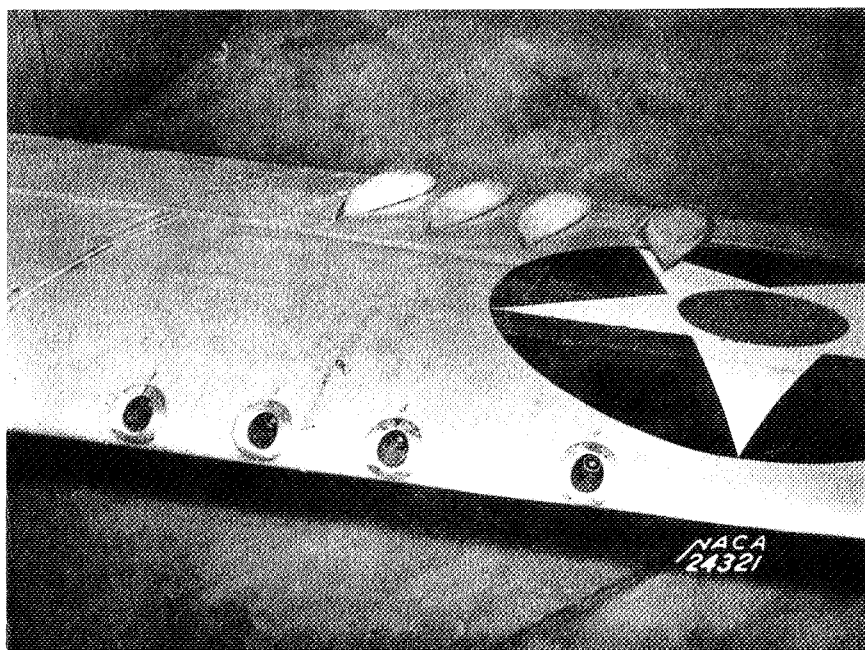
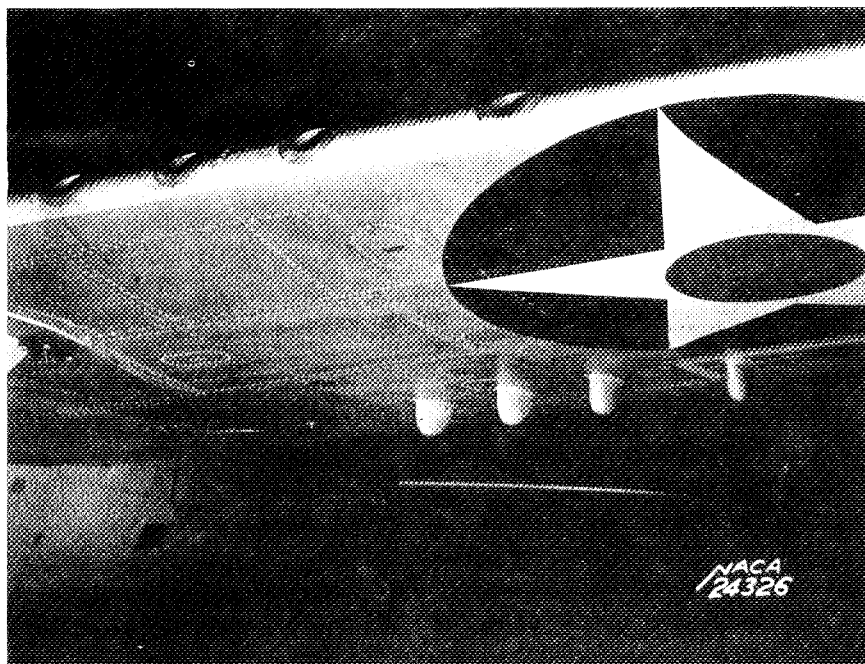


Figure 6.- Flush machine guns in the high position on left wing.

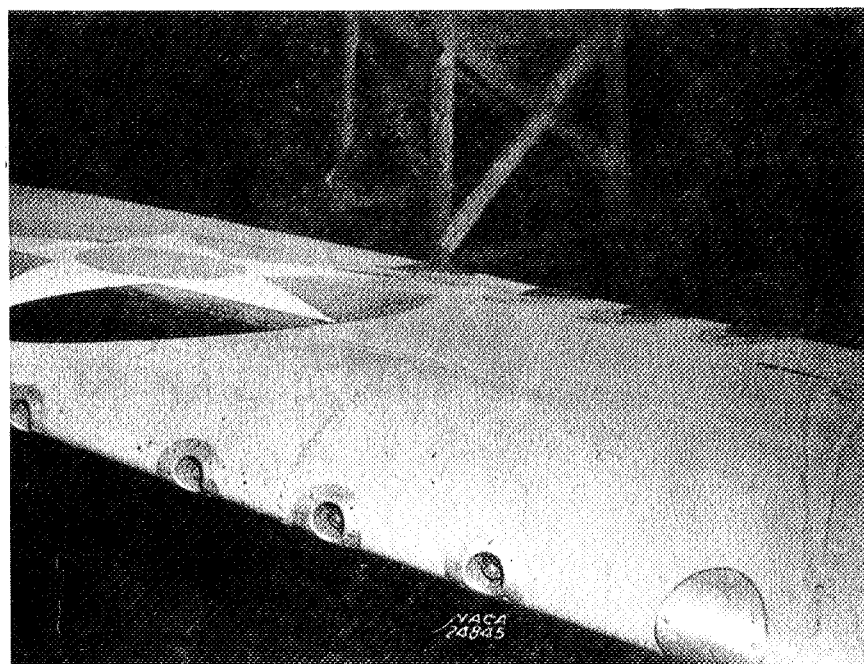
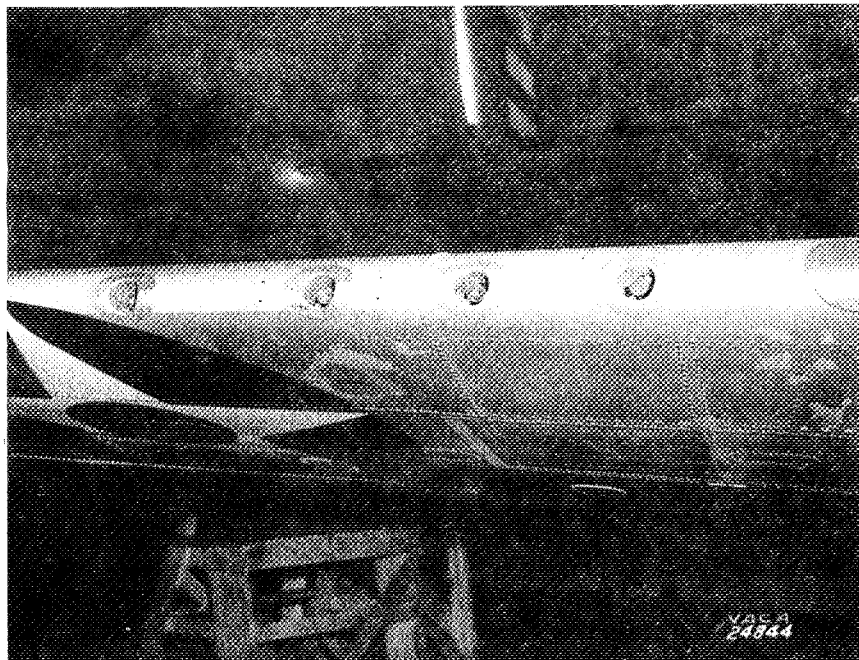


Figure 7.- Flush machine guns in the low position on the right side.

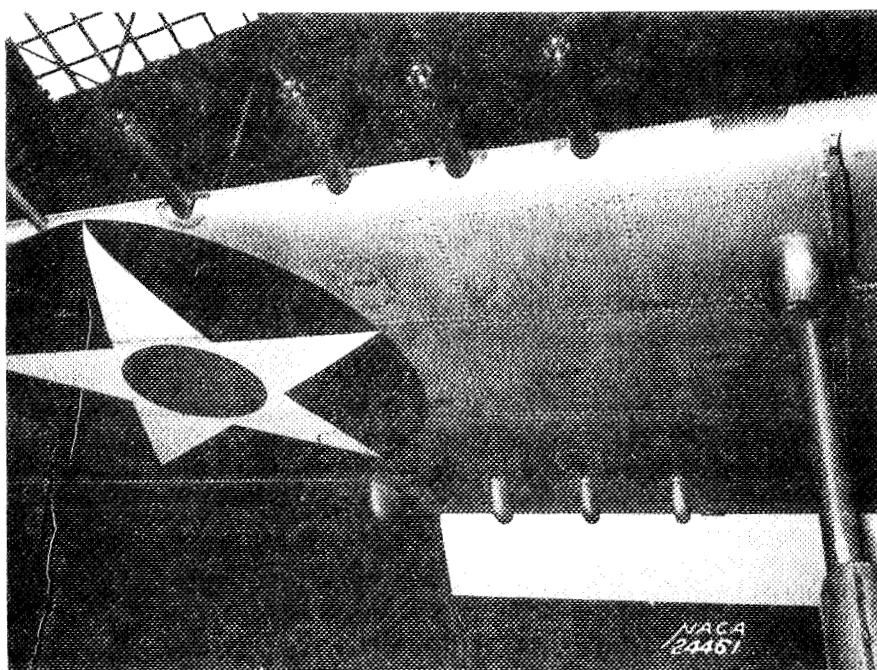
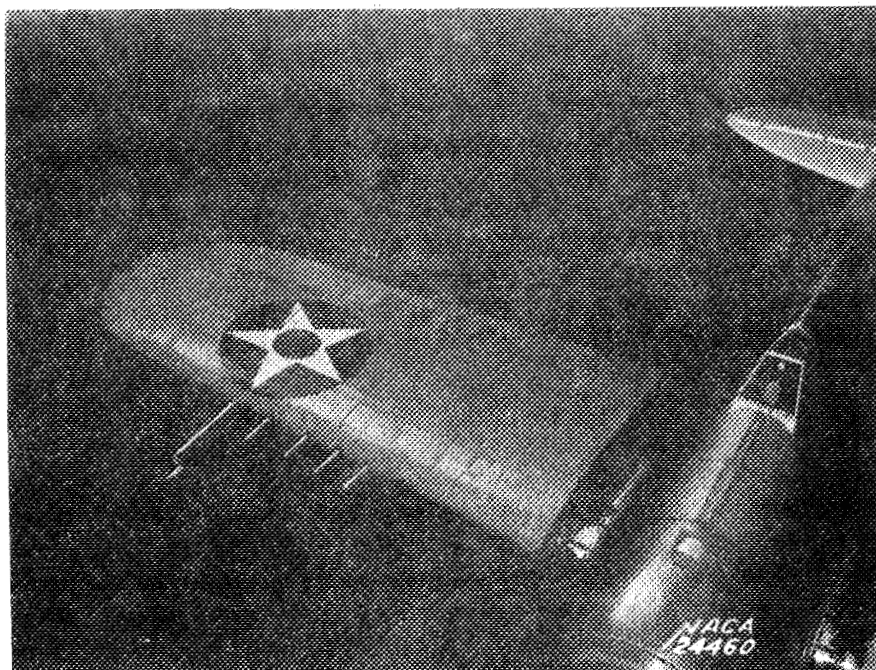


Figure 8.— Ten-inch extensions with flush-gear low-position fairings.

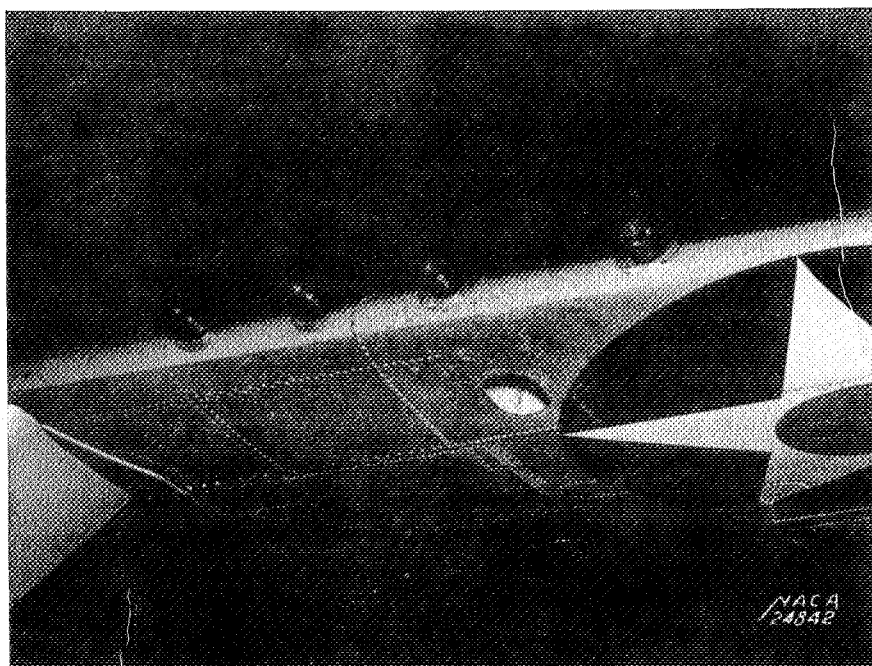
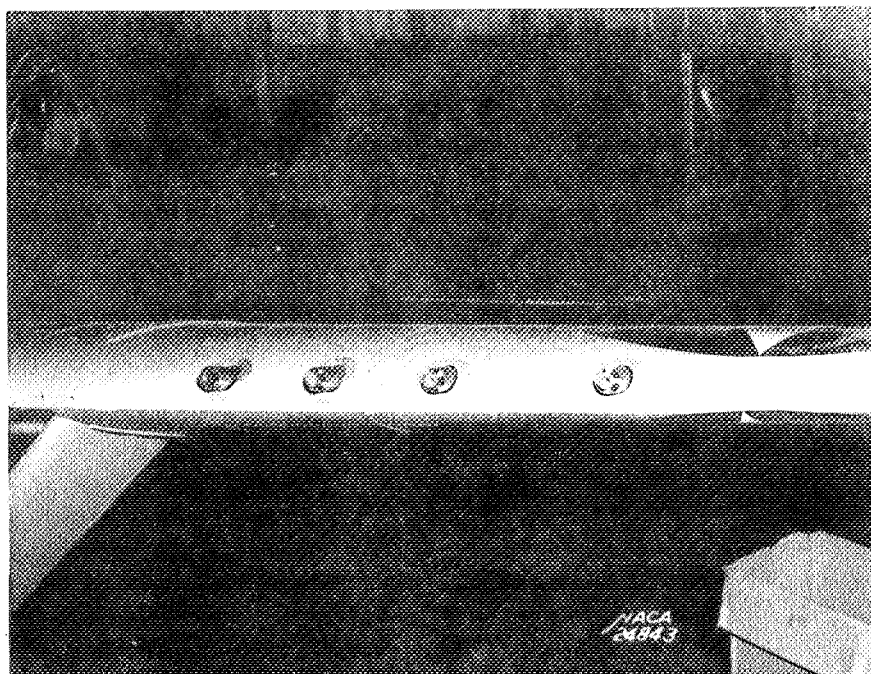


Figure 9.-- Two-inch extensions in the high position on the left wing.

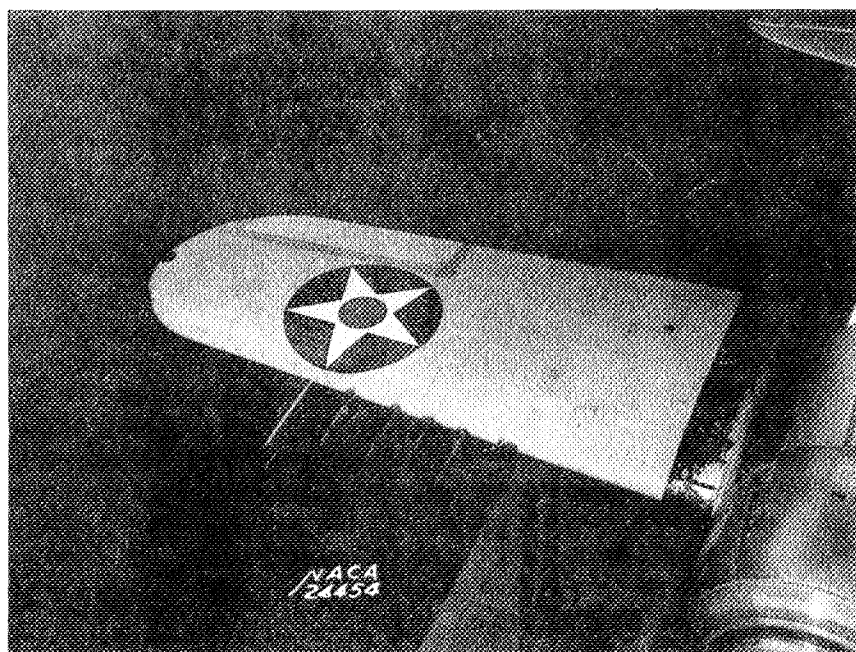
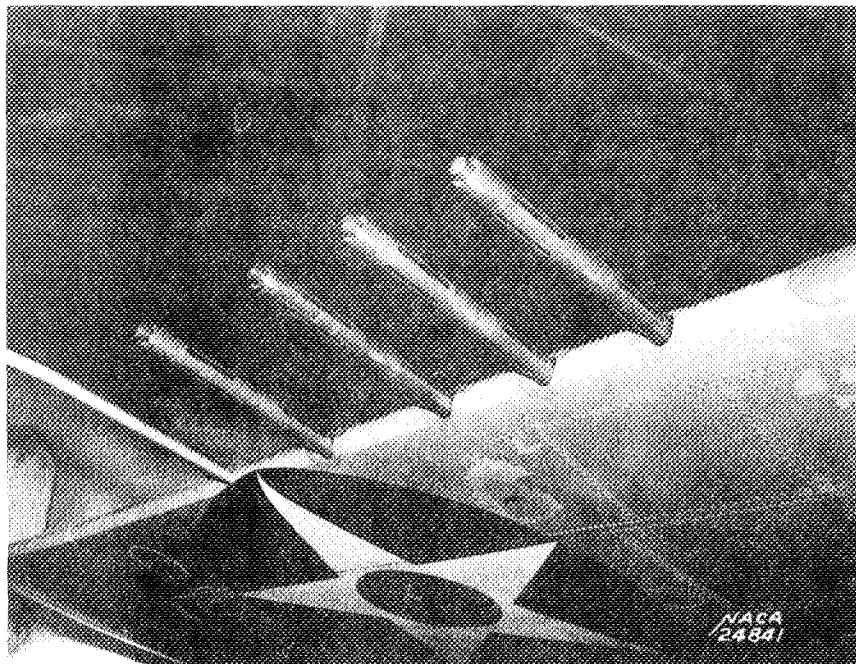


Figure 10.-- Eighteen-inch extensions in the low position on the right wing.

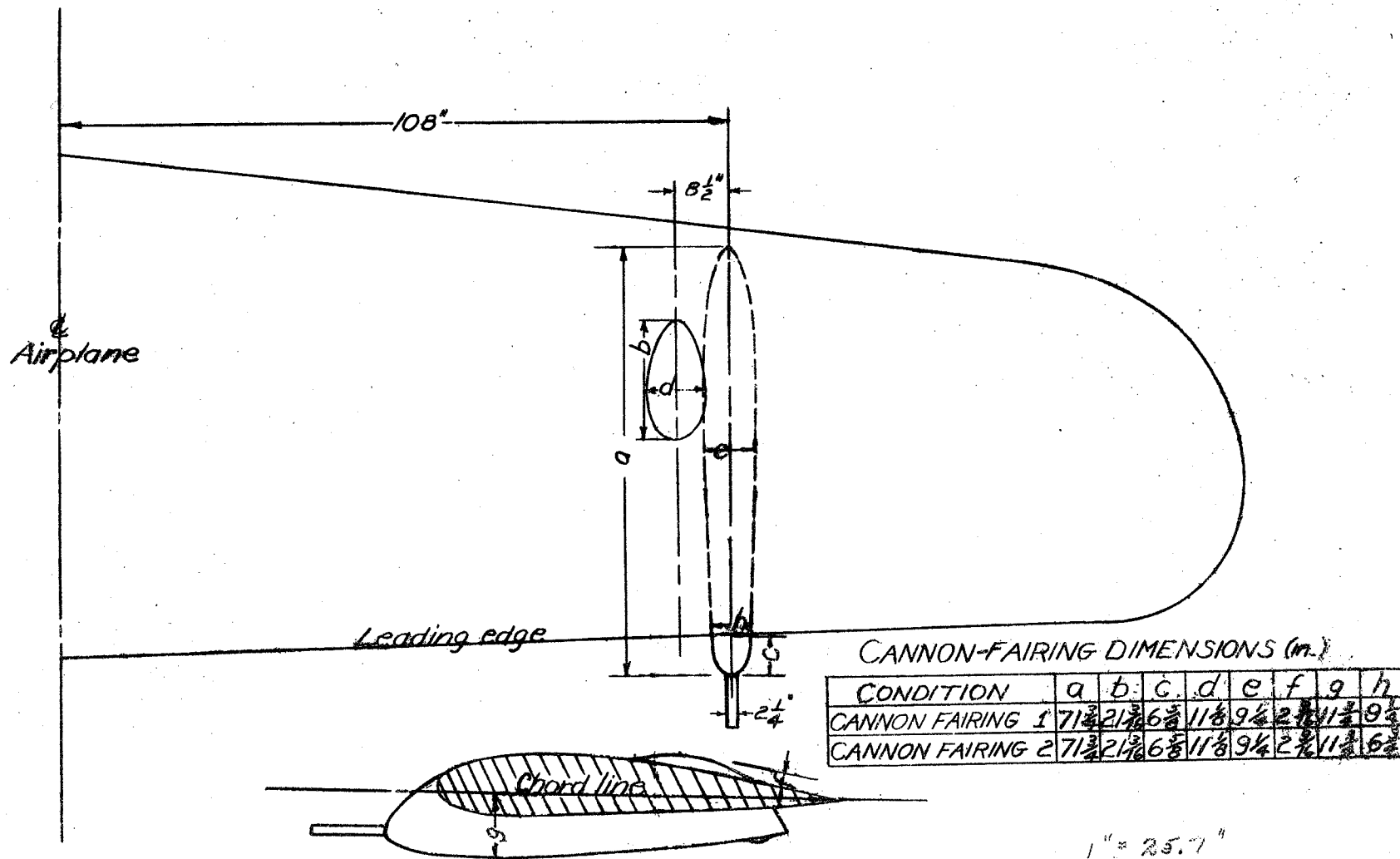


FIGURE 11.- UNDERSLUNG-CANNON INSTALLATION AND MODIFICATION.

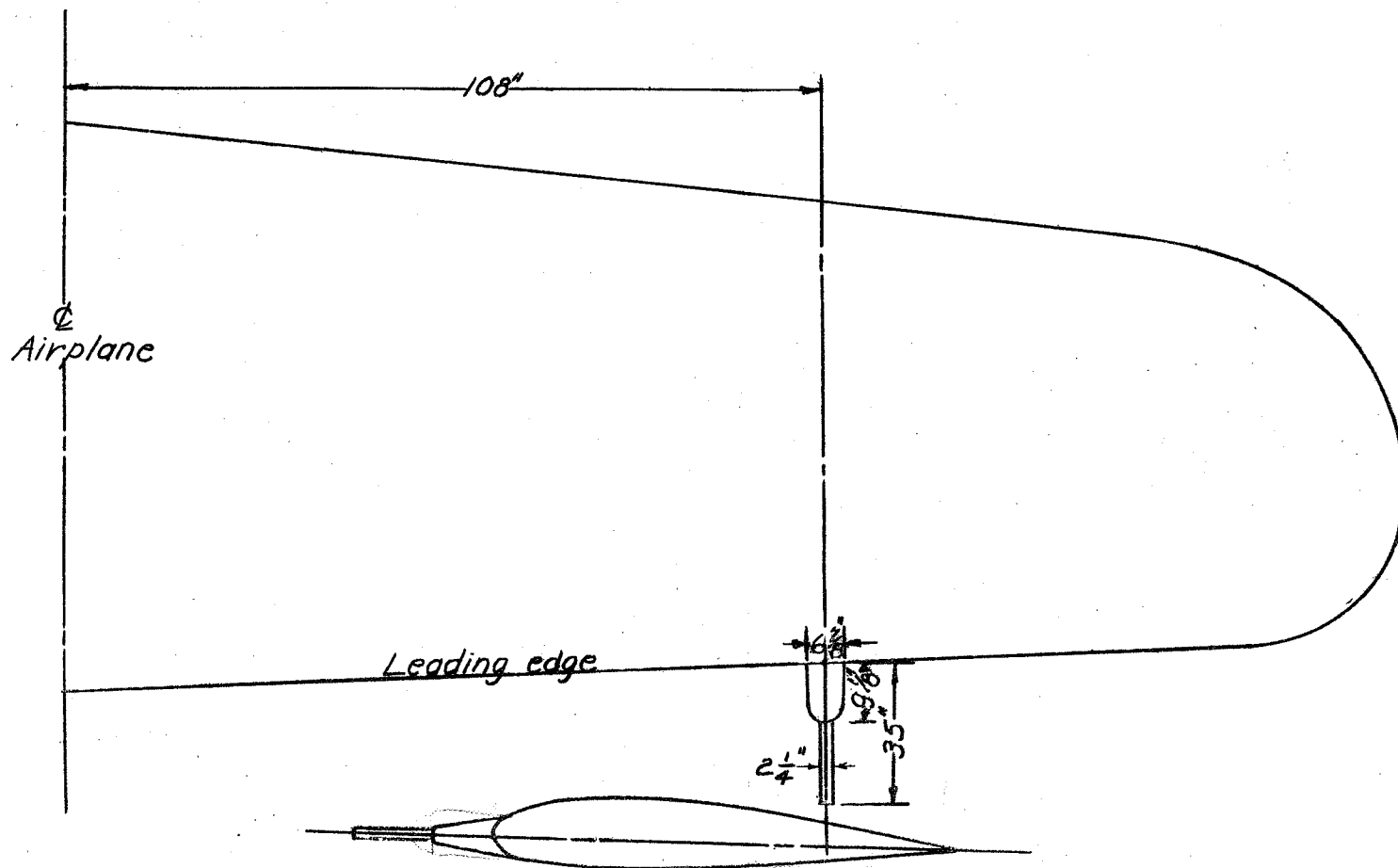


FIGURE 12.- SUBMERGED-CANNON INSTALLATION.

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Fig. 13

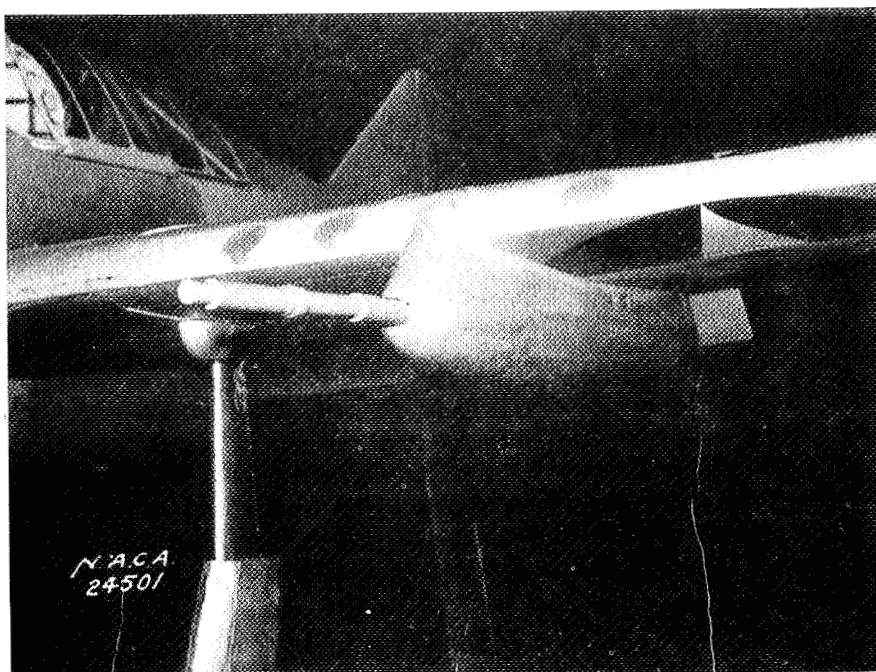
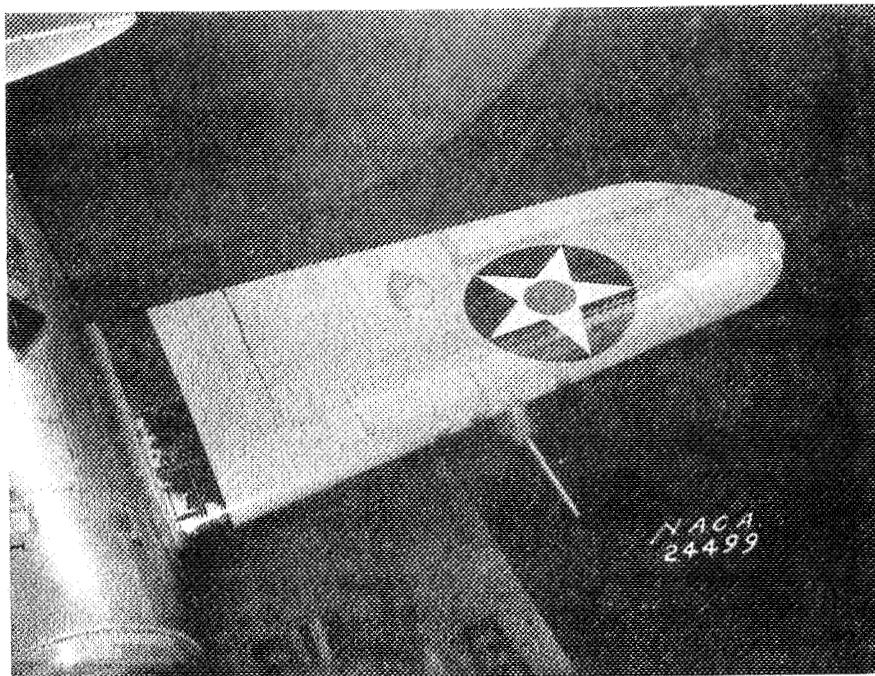


Figure 13.- Underslung cannon installation, 1.

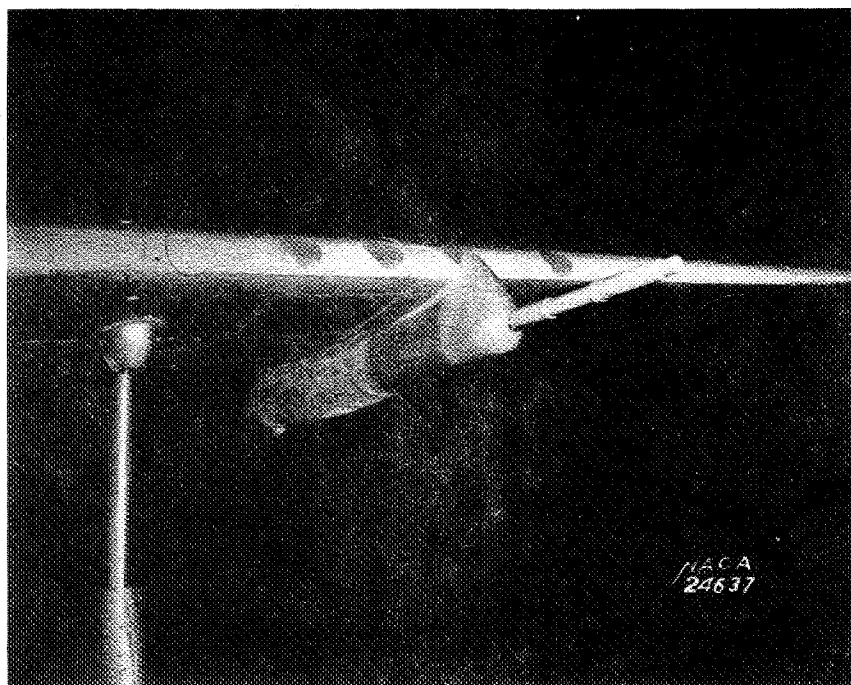


Figure 14.- Modified underslung cannon installation, 2.

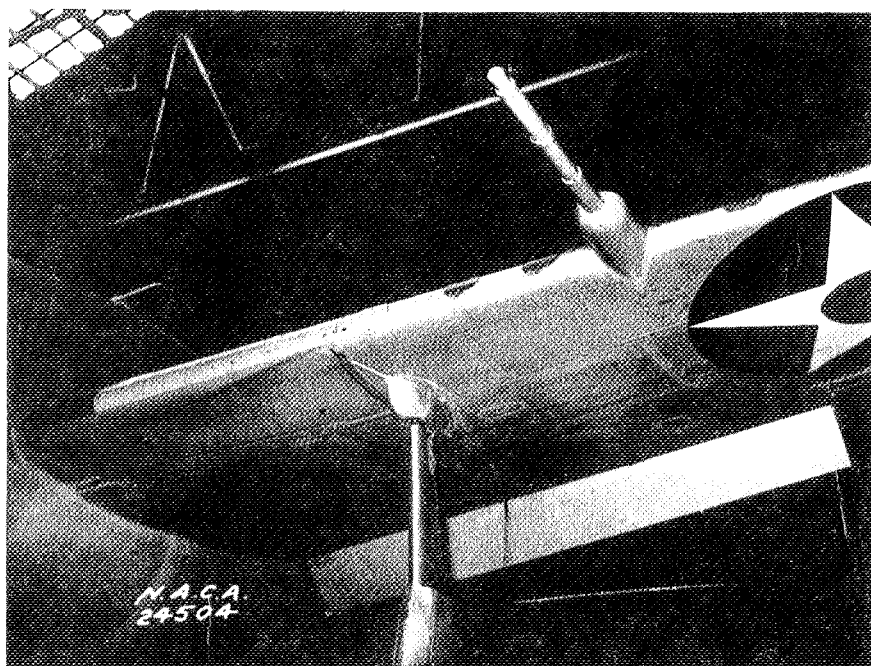
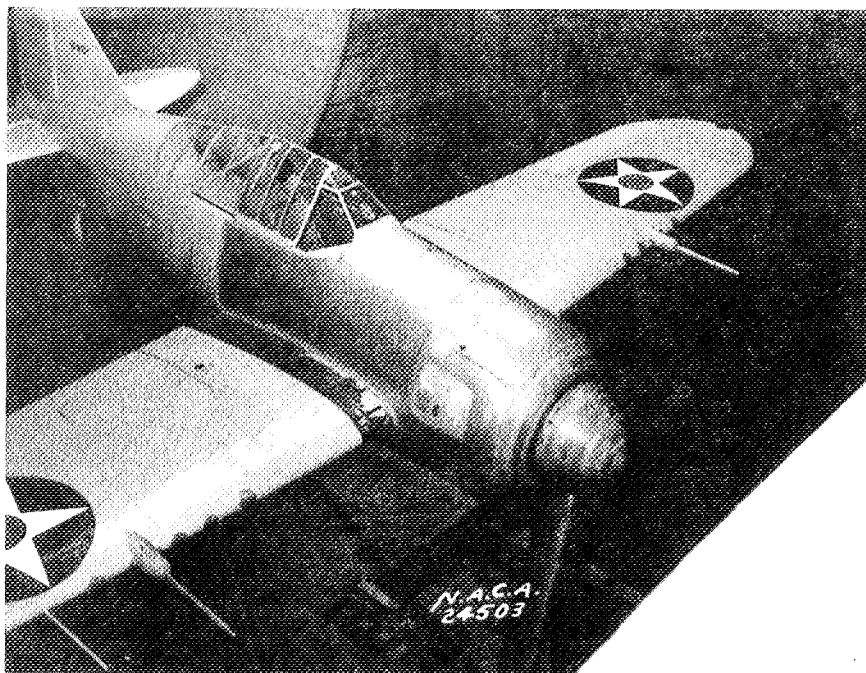


Figure 15.- Submerged cannon installation.